Enabling Low Cost Planetary Missions Through Rideshare Opportunities

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June 20, 2013

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A Low Cost Approach for Exploration

CubeSats have revolutionized Earth science mission by providing regular, low-cost access to space through standardization.

Regular access to space provides various ways to lower-cost:

1. Higher Risk Approaches
2. Increased community for operating missions
3. Innovative uses of technology
4. More Focused Science Investigations

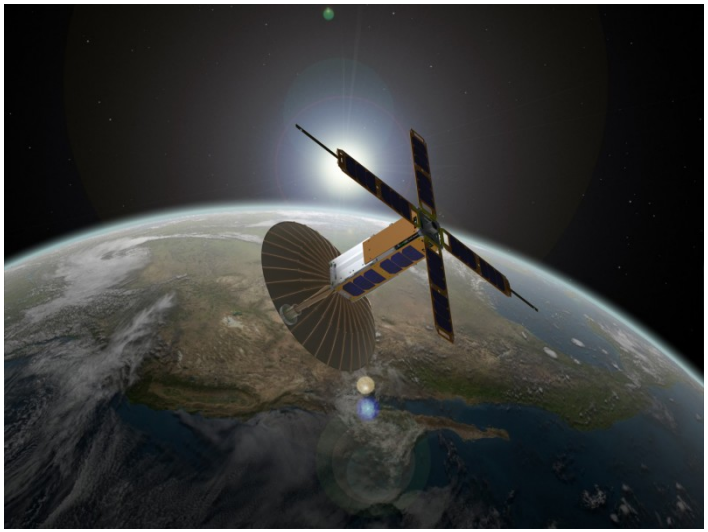

Photo Credit: USC AENES Project

What approach could be used to reduce cost for Planetary Science missions?

Deep Space Travel is Not Easy!

Stand-alone Planetary CubeSat missions must overcome significant technological hurdles to succeed

Photo Credit: NASA/KSC

Long distance communication requires increased power or antenna area

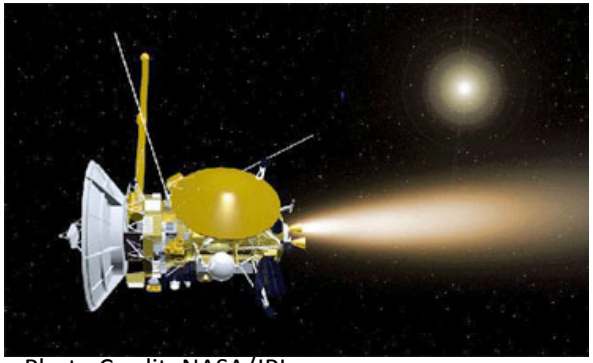

Photo Credit: NASA/JPL

Propulsion systems require increased potential energy or power

The result is a **significant increase in complexity** in order to force the Deep Space functionality to fit within the **current CubeSat standard**

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CubeSats As Daughter Craft

The reduced number of planetary launches results in less opportunities for Cubesats in the Mother-daughter architecture

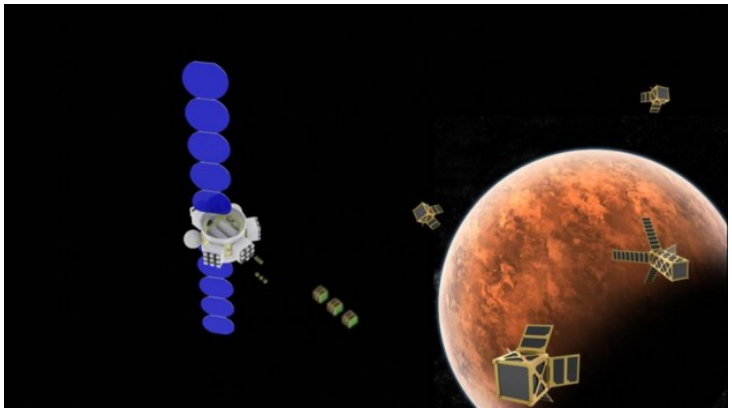
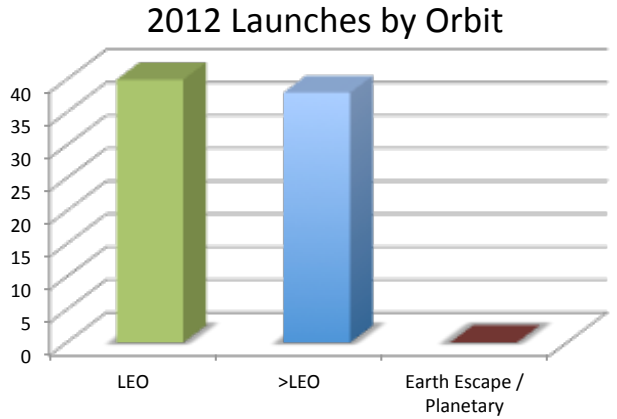


Photo Credit: Busek

Relies on a much more expensive mission (higher quality assurance)

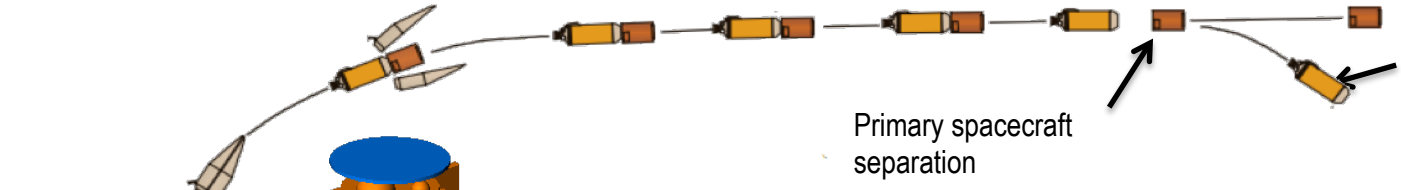


Reduced number of launch opportunities (requires higher reliability)

The reduction of opportunity forces **more consideration for mission reliability and quality assurance, increasing the cost and complexity** of the systems

A New Approach

Increased access to the inner solar system could be enabled by combining the ESPA ring launch flexibility with lunar gravity assists



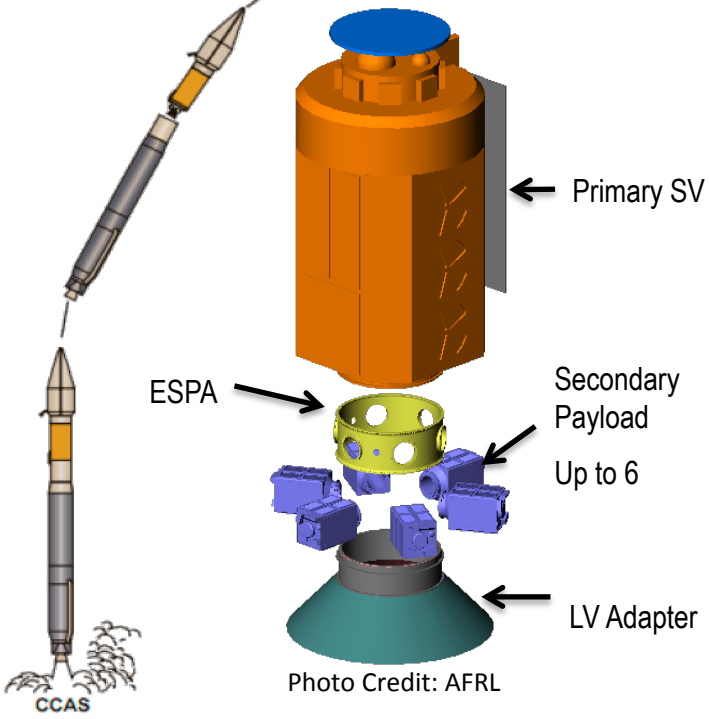


Photo Credit: AFRL

Photo Credit: Lockheed Martin

ESPA Ring

- The EELV Secondary Payload Adapter (ESPA) provides a standard launch interface for spacecraft <180kg per slot

Lunar Gravity Assists

- Lunar gravity assists can be used to customize the departure energy and direction to any potential target of interest including NEOs, Venus and Mars

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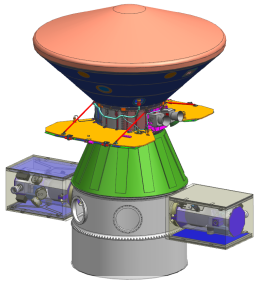
Potential Platform for Planetary Exploration

The 'Micro Surveyor' spacecraft concept combines the launch flexibility of a CubeSat with the performance of a Deep Space spacecraft

Single string spacecraft with a launch mass of <75kg

Easily fits within the defined volume for the ESPA ring (24"x28"x35.5")



Two 1.5m^2 deployable solar arrays provides ~750W of power

Capable of delivering up to 15kg of science payload

Rad hard cubeSat based avionics and attitude determination provides sufficient computing and pointing control

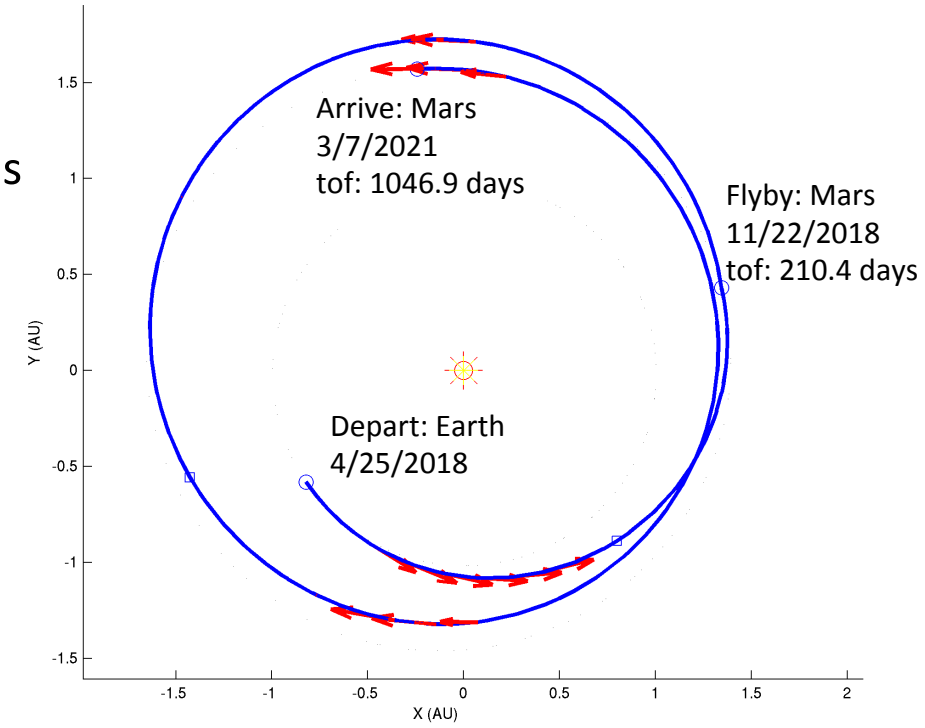
JPL developed X-band telecommunication system provides navigation and communication

COTS low-power EP system provides up to 5.4 km/s of ΔV for flight to Mars, Venus or NEOs

Potential Targets of Interest

From GTO, Planetary Science mission could potentially be conducted at Venus, Mars and NEOs

- Example Mars Trajectory
  - Launch date: December 2017
  - Time to Earth Departure: 6 months
  - Transfer flight time: ~3 years
  - Mars Arrival Time: March 2021
  - Total Delta V to Mars: 2.35 km/s
- Venus and NEO Trajectories
  - NEOs
    - Launch in late 2019
    - Flight time of ~21 months
  - Venus
    - Launch in late 2018
    - Flight time of ~16 months to Venus



Summary

- A new standard needs to be developed to provide the launch regularity that enables interplanetary low-cost flight.

- An extension of the CubeSat Launch Initiative using the ESPA ring would increase the opportunity for planetary science by providing rideshare opportunities on GTO, Lunar or Low C3 launches

Photo Credit: NASA

- 'Micro Surveyor' is an example of a spacecraft concept that leverages CubeSat technologies and provides the required capability to access deep space targets from Mars to Venus using regularly available GTO launch opportunities